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## Guidance Document for performing LCAs on Fuel Cells and H<sub>2</sub> Technologies

### CRITICAL REVIEW STATEMENT AND RESPONSE SUMMARY - REVIEW ACCORDING TO THE ILCD-HANDBOOK AND ISO 14040 AND ISO 14044 -

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**Approved by the**

**X External reviewer**  
**X Work Package Leader**  
**X Project Coordinator**

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**Abstract:** This document summarises the review process of the guidance documents on hydrogen production and fuel cell technologies. It describes the review procedure itself, and summarises the most important review comments. In addition the review panel members are introduced by a short CV.

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## 1. Introduction

The documents to be reviewed - built on the International Life Cycle Data System (ILCD), developed by JRC-IES, through the European Platform on LCA, and applied to both Hydrogen production and Fuel Cell technologies – aim to foster and facilitate LCA applications, especially among industries, giving provisions on how to perform each step of the LCA procedure, with detailed information on how to deal with key methodological aspects like: definition of functional unit, system boundaries setting, allocation rules, relevant impact categories, etc. These documents are the main deliverables of two separate projects coordinated by ENEA (Italy) and PE INTERNATIONAL AG (Germany) for the *Fuel Cells and Hydrogen Joint Undertaking (FCH JU)*, who has preferred them to be somehow run together, because of the clear interlink between both sectors in the market. Therefore, the review process has run in parallel for both projects as well.

As it is stated in the Guidance Documents' Introduction:

*“The GD (Guidance Document) is foreseen to be applied to all projects funded by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) requesting LCA in the field of H<sub>2</sub> production and fuel cell technologies. By providing information on how to deal with key methodological aspects of LCA (for example, definition of a functional unit, system boundary, allocation rules, relevant impact categories, etc.), the GD will allow each hydrogen production and fuel cells technology developers to assess their own technology, and make the information available in the ILCD Data Network. The availability of data sets will therefore be increased and future LCA studies in this field supported.”*

The objective of this review is to check the compliance of the GDs with the ILCD Handbook, focussing on comparing the provisions of the GDs with those of the ILCD Handbook, together with, as far as possible, the LCA good practice and general concepts such as readability or operability. This review is not a certification and the reviewers hold no liability upon the result of it. The reviewers have performed their task without certain boundary conditions and up to their knowledge, and may very well have not found all discrepancies between the GDs and the standards against which the review was performed.

## 2. Description of the reviewing procedure

On 2010-10-14, the practitioners announced to the review panel and to the JRC-IES (Advisory board) that the kick-off meeting of the project took place during that week, asking to initiate the review process. The first step was for the practitioners to write the first drafts of the two guides, to be handed to the review panel/ Advisory board in January (finally sent beginning of February) for first review during a Technical Expert Workshop to be held during 14-15 of February 2011 in Brussels. At that time, the review panel was formed by: Dr. Pere Fullana i Palmer, Michael Bode and Dr. Paolo Frankl<sup>1</sup>. Having the interaction between the practitioners and the review panel/ advisory

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<sup>1</sup> During the review process, Dr. Frankl was substituted by Prof. Dr. Matthias Finkbeiner. Short CVs of Advisory Board members can be found in Annex 1.

board started at such an early stage of the guides drafting, this review can be considered as an accompanying or interactive one.

The workshop was attended by the practitioners, the JRC-IES, the review panel and a long list of technical and LCA experts<sup>2</sup>, and had fruitful discussions. This Board subscribes to what was written in the workshop minutes:

*“On 14th and 15th of February 2011, the FC-HyGuide Technical Expert Workshop was held in the Royal Flemish Academy of Belgium for Science and Arts in Brussels. Organised in the framework of the FC-HyGuide project, the workshop grouped experts from both research and industry, to present and discuss the first draft of the “Guidance document for performing LCAs on Hydrogen and Fuel Cell Technologies”.*

...

*The workshop, organised in parallel sessions for discussing the specificities of each technology, was characterised by a fruitful discussion among all the participants. The discussion focused mainly of the choice of functional unit and on the system boundaries definition.*

...

*The active involvement of the participants allowed fine-tuning the document to the industry needs, avoiding a too academic treatment of the topic, but taking into consideration the expectation of the practitioners (both LCA practitioners and technicians in industry).”*

Next step of the review process was a public consultation held during the whole month of April 2011. A comments' template was provided in addition to collect feedback and comments.

Feedback gained during the public consultation was then integrated in the GDs by the two consortia.

On June 3<sup>rd</sup>, the review panel was told about the progress of the GDs and Dr. Fullana was chosen as Review Panel Chair. The GDs had passed the public consultation and were sent as a final draft to the review panel /advisory board on June the 16<sup>th</sup> (Hydrogen Production Technologies GD) and June 21<sup>st</sup> (Fuel Cell Technologies GD). A comments' template was distributed by the practitioners to the review panel/ advisory board for implementing the review process.

The review was developed in four rounds, after each of which a teleconference was held. The teleconferences were held on June 28<sup>th</sup>, July 12<sup>th</sup>, July 25<sup>th</sup> and August 3<sup>rd</sup>. Given the difficulties of one of the reviewers, Dr. Paolo Frankl, to participate in the review process, the Panel Chair suggested and contacted an alternative reviewer, Prof. Dr. Matthias Finkbeiner, who accepted to enrol the review team and who was given more time to perform his review. The initial teleconference helped to format the review process and the result was a number of general comments about the GDs, including the decision to focus the review on the ILCD Handbook Detailed Guidance provisions and not the rest of the text. Then, the second round was focussed on the Goal and Scope Definition part, followed by the Inventory Analysis part in the third one, and the Impact Assessment and Interpretation parts for the fourth round.

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<sup>2</sup> The complete list can be found in Annex 2

After the last review meeting, the practitioners wrote the final documents which were sent to the review panel on September the 7<sup>th</sup> for a final check before the last teleconference of this review process, which took place on September 12. The practitioners asked the panel chair to write a document summarising the review process and results. It was decided that the working documents, with all the review comments and responses by the practitioners, will be kept internally, while this summary document will be added to the project deliverables.

All the process has been followed by the European Platform on LCA (JRC, European Commission), mainly by Ms. Kirana Chomkham Sri, who actively participated in the review process.

The review team wishes to thank the practitioners for the fruitful discussions at all times and their open-minded attitude in relation to this panel's comments.

### **3. Summary of the most important review comments**

#### **3.1. Readability**

In relation to readability, there was a concern because the GDs used different chapter numbers than the ILCD Handbook or ISO 14044.

However, during the review process the practitioners pointed out that keeping the same numbering of the ILCD was not possible for the following reason. In fact, being the GD a sector-specific guidance, which "translate" the ILCD, the information and issues covered are necessarily condensed and made product-specific whenever possible. Thus, the numbering is not always followed. The practitioners believe that this aspect will not affect the understanding of the content of the GDs since the final users will have the opportunity to easily refer to the ILCD for those aspects that need further clarification.

An unsolved issue, to be raised at the beginning of the development of any other further GD, is the way the text from ISO 14044 is used. One option could be not to write within the GD any provision of ISO 14044 and just cite its chapters. Then, the GD would have new text only. Another option would be to include the text of the standard within the GD and add explanation text or new provisions on top of the ones by the standard. These two GDs have included some (the most important, according to the practitioners) ISO provisions and not others. This fact may make the reader think that the ones not included are not to be followed, which is not the case. This is against the wish by the practitioners that the GD can be used without the ISO standards in hand.

The same can be said in relation to the ILCD Handbook. However, with the handbook the problem is even bigger. The GDs are needed because the Handbook is very comprehensive and, at the same time, not sector specific. If a GD has to include everything required by the Handbook (in addition to what ISO requires) and has to be tailored to take into account the specificity of the sector, with the aim of being a stand-alone-document, the resulting document will be even bigger than the Handbook, making it not practical. JRC needs to give a clear guidance about this point to future GDs.

Also for other GDs to come, it is important to include all "shalls" and "shoulds" within the provisions' text boxes and the explanatory text outside them. This correction made the GDs more readable. In addition, as the target group of both GDs is similar, having

the same chapter numbering has increased readability. We recommend continuing with this numbering for the next GDs, as far as possible.

Sometimes, terms were unclear and were changed where possible, like the alternative use of “module” and “stack” within the FC GD, which was solved by only using “stack”, or confusing data adjectives such as “secondary”, “average”, “mix”, “background” or “generic”.

### **3.2. Operability**

In general, the additional specification compared to the ISO-standards is relatively limited. Some readers may have expected more specific requirements, like the ones provided in a PCR<sup>3</sup> document.

The GDs have included a statement in which it is said that they are only applicable to “Situation A” of the ILCD Handbook.

Figures and specific examples have been added to the review panel request. This one may be the most important issue in any GD: for the GD to be useful and operational, it is essential that the explanatory text is sector specific as well. Examples of this are the inclusion of specific processes to be included within the system boundary and the relevant flows, the target audiences, the functional unit, how to deal with multi-functionality, normalisation, a priori significant issues and uncertainties, consistency check, etc.

### **3.3. Methodology**

Goal and Scope Definition was without any doubt the section with the highest need of discussion. This is obvious, as it is the longest section within the ILCD Handbook and it is the methodology phase with the highest consequences on the results of LCA studies.

Attention has been given that the documents take ISO 14044 and the ILCD Handbook as minimum requirements; for example, that a “should” in them can be a “shall” in the GDs but not the other way around.

It was asked to both GDs to be harmonised in methodology like, for instance, to follow the same cut-off rules structure or the same secondary data selection procedure.

A good discussion was held on data quality requirements. The conclusion was that it was necessary for the GDs that the data quality requirements were adapted according to the ILCD handbook. Indications were given both for the full compliance and the entry-level compliance and the GDs were also provided with minimum data quality levels both for primary and secondary data.

Some comments were given and addressed in relation to the use and end of life phases of the life cycle of the systems under study. Attention was given to the identification of what was to be considered foreground and background parts of the system.

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<sup>3</sup> PCR, Product Category Rules within an Environmental Product Declaration Programme.

Quite a lot of effort has been given to the provisions which consider comparative assertions. Issues like the need to use a complete set of impact indicators (and not only carbon footprint, for instance) or the different review types depending on the intended application were included. Being the critical review issue one that goes beyond ISO in these GDs and having acknowledged the somehow confusing text in the Handbook, the result of this provision is recommended to be used by future GDs. In addition, being the critical reviewer qualification requirements within the ILCD Handbook very difficult to be met, it is important to follow the provision decided within these GDs.

Aggregation and weighting of impact categories was described as a methodology step that is not scientifically based, as stated in ISO 14044. About normalisation, it has been added that it must never be aggregated across impact categories and that more than one reference system is needed for comparative assertions.

Also in relation to impact categories, more explanation was asked to be included on what to have in and out and why. Specific information was asked for biodiversity impact category, because of its policy importance (and incomplete development), and to energy indicators, because of the nature of the sectors addressed by these GDs.

Finally, interpretation was a good chapter for discussion. Effort has been put in order to integrate and further explain all steps within the interpretation phase. Issues discussed include: significant issues, cut-off criteria, incompleteness, reporting changes in goal and scope, the need of an uncertainty check, worst and best case scenarios, etc.

### **3.4. Issues without consensus between the practitioners and the reviewers**

The few unsolved issues which remained after the last conference call of the review process were solved during the edition of the final document, as declared by the practitioners, and consensus between practitioners and reviewers could be reached.

## **4. Documents used by the review team**

Guidance document for performing LCA on Hydrogen Production Technologies  
Guidance document for performing LCA on Fuel Cell Technologies  
International Reference Life Cycle Data System Handbook (ILCD handbook). General guide for Life Cycle Assessment – Detailed guidance.  
ISO 14040:2006 - Environmental Management. Life Cycle Assessment. Principles and Framework  
ISO 14044:2006 - Environmental Management. Life Cycle Assessment. Requirements and Guidelines

Barcelona, 2011-09-26



Dr. Pere Fullana i Palmer (chair)  
on behalf of the review panel

## **Annex 1. Short CVs of review panel members**

### **Dr. Pere Fullana i Palmer**

Dr. Fullana i Palmer, studied chemical engineer (Final Project Award 1988) at Institut Químic de Sarrià (IQS, URL, Barcelona) and Industrial Engineering at UAB. He continued with a PhD Degree in Industrial Engineering at Universitat Ramon Llull. He is the Director of the UNESCO Chair in Life Cycle and Climate Change at Escola Superior de Comerç Internacional (Universitat Pompeu Fabra), a research group that has been awarded with the Environmental Award 2008 by the Government of Catalonia. From the very beginning, he is the Spanish delegate for drafting the ISO on LCA, eco-design and eco-labelling and also for drafting the CEN regulation on LCA for packaging and ecolabels in construction materials. Currently he is a member of the International Life Cycle Board of the UNEP-SETAC Life Cycle Initiative. He has been involved in writing the Product standard of the Green House Gases Protocol by the World Business Council for Sustainable Development and is a former Chair of the LCA Steering Committee of SETAC Europe. He has received a number of honours, including the Award for the Most Significant Contribution to the International Life Cycle Management Conference (LCM 2009).

He has participated in more than 150 LCA studies and published numerous articles. Dr. Fullana is an experienced LCA Critical Reviewer with more than 20 participations, including the review of the ILCD Handbook chapter on Critical Review.

### **Prof. Dr. Matthias Finkbeiner**

Prof. Dr. Matthias Finkbeiner is currently Chair of Sustainable Engineering and Vice-Director of the Department of Environmental Technology at Technical University Berlin. He is also Advisory Professor at Aalto University in Finland, Chairman of the ISO-Committee TC207/SC5 for Life Cycle Assessment, member of the International Life Cycle Board (ILCB) of the UNEP/SETAC Life Cycle Initiative and the Steering Committee of the Greenhouse Gas Protocol Product/Supply Chain Initiative of the World Business Council for Sustainable Development. Earlier in his career, he was Manager for Life Cycle Engineering at the Design-for-Environment Department for Mercedes-Benz Cars at Daimler AG in Stuttgart and Vice-Director Environmental Management at PE International.

### **Michael Bode**

Michael Bode retired end of February 2010 as Managing Director of the German company MTU Onsite Energy GmbH (formerly CFC Solutions GmbH), a leading supplier of high temperature fuel cell (MCFC) systems for cogeneration & trigeneration under the registered trademark "HotModule". As of March 2010 Mr. Bode is working as freelance consultant with a focus on business development and on managing innovative business opportunities (mibo-consult).

Mr. Bode has more than thirty years' experience in the business development of new technologies, since 1990 particularly in the hydrogen and fuel cell field and in public/private partnerships. He was and is actively promoting and supporting the development, demonstration and commercialization of fuel cell technologies in Europe. He held a number of Board member positions in the industry. He was Member of the Board of Fuel Cell Europe on behalf of MTU Onsite Energy and Founding Member of the European JTI Industry Grouping (Joint Technology Initiative for Hydrogen and Fuel Cells).

## **Annex 2. List of the Technical Expert Workshop participants**

- Carlos Navas (FCH JU) (14 Feb in the morning only)
- Mirela Atanasiu (FCH JU) (14 Feb in the morning only)
- Norbert Frischauf (European Commission - Joint Research Centre - Institute for Energy)
- Alessandro Agostini (European Commission – Joint Research Centre - Institute for Energy)
- Michele Galatola (European Commission – EU Label)
- Pere Fullana (Escola Superior de Comerç Internacional)
- Oliver Kusche (Karlsruhe Institute of Technology - Institute of Applied Informatics)
- Paolo Frankl (IEA – International Energy Agency) (15 Feb only)
- Heiko Maas (Ford Forschungszentrum Aachen)
- Jean Francois Larive (CONCAWE)
- Michael Bode (MIBO Consult)
- Dimitrios Giannopoulos (National Technical University, Athens - Laboratory of Heterogeneous Mixtures & Combustion Systems)
- Dimos Kontogeorgos (National Technical University, Athens - Laboratory of Heterogeneous Mixtures & Combustion Systems)
- Karl-Heinz Kettl (Technical University Graz - Institute for Process and Particle Engineering)
- Paolo Masoni (ENEA - Italian National Agency for New Technologies, Energy and Sustainable Development)
- Angelo Moreno (ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development)
- Rita Mubbala (PLANET GbR – Engineering and Consulting)
- Klaus Stolzenburg (PLANET GbR – Engineering and Consulting)
- Robert Steinberger-Wilckens (PLANET GbR – Engineering and Consulting)
- Sergio Ulgiati (DiSAm - Department of Environmental Sciences)
- Alessandra Zamagni (ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development)
- Amalia Zucaro (DiSAm - Department of Environmental Sciences)
- Moschoula Krambousanos (European Hydrogen Association)
- Frano Babir (University of Split)
- Thomas Feck (Next Energy)
- Michael Provost (Intelligent Energy Ltd.)
- Werner Weindorf (Ludwig-Bölkow-Systemtechnik GmbH)
- Oliver Schuller (PE International AG)
- Sven Lundie (PE International AG)
- Aleksandar Lozanovski ( University of Stuttgart – Department Life Cycle Engineering),